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(54) **INTEGRATED CONTROLLER-PILOT DATALINK COMMUNICATION SYSTEMS AND METHODS FOR OPERATING THE SAME**

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H04B 7/185 (2006.01)
G02B 27/01 (2006.01)

(52) **U.S. Cl.**

CPC ***G08G 5/0013*** (2013.01); ***G02B 27/0101*** (2013.01); ***G08G 5/0021*** (2013.01); ***H04B 7/18506*** (2013.01); *G02B 2027/0141* (2013.01)

(58) **Field of Classification Search**

CPC G08G 5/0013–5/0021; H04B 7/18506
See application file for complete search history.

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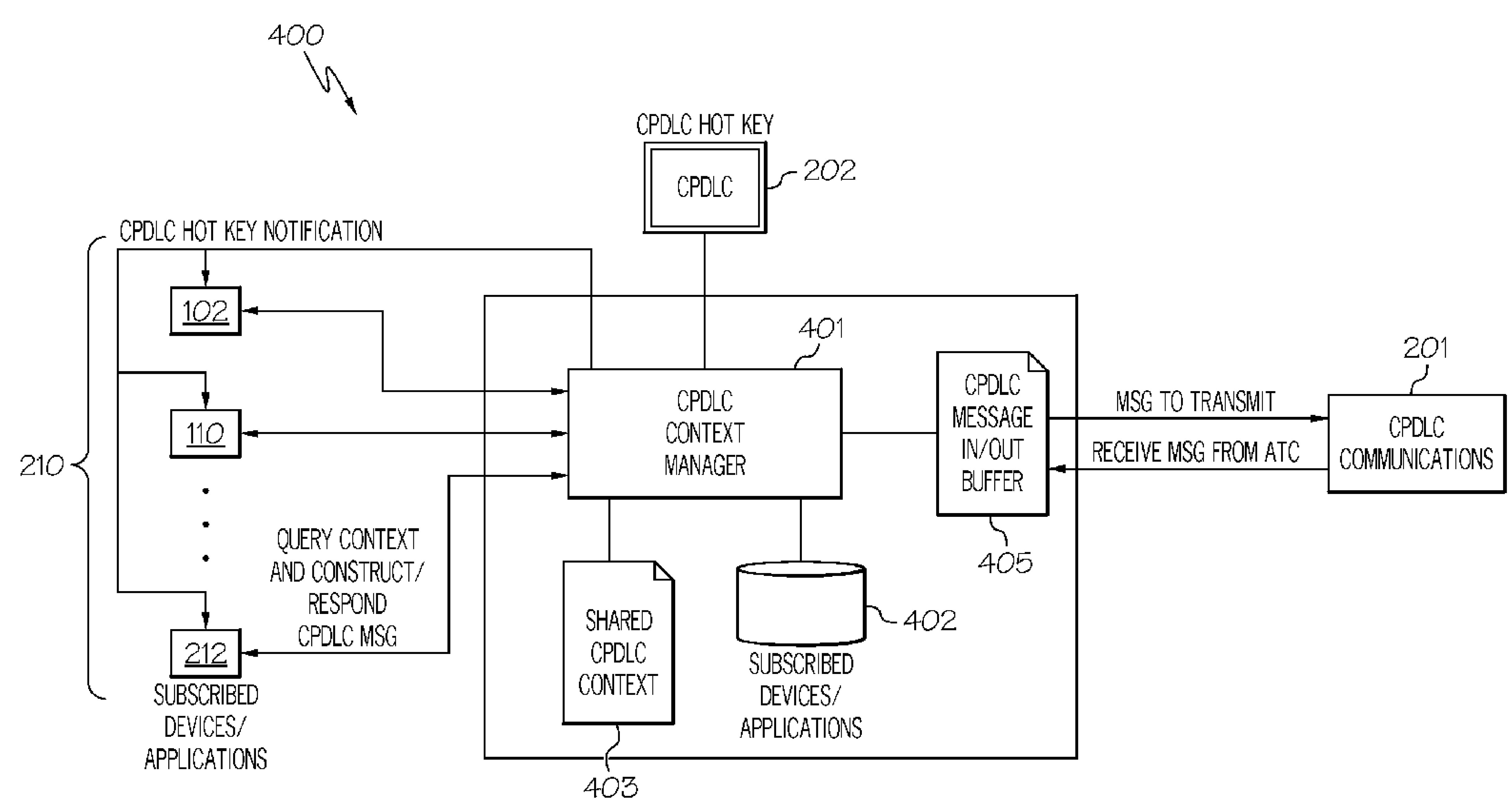
(57) **ABSTRACT**

Integrated controller-pilot datalink communication (CP-DLC) systems and methods for operating the same are disclosed. In one implementation, an integrated CPDLC system includes a plurality of CPDLC-enabled avionics devices and a CPDLC context manager coupled with each of the plurality of CPDLC-enabled avionics devices. The CPDLC system further includes a shared CPDLC context memory coupled with the CPDLC context manager and a CPDLC message in/out buffer coupled with the CPDLC context manager.

9 Claims, 7 Drawing Sheets



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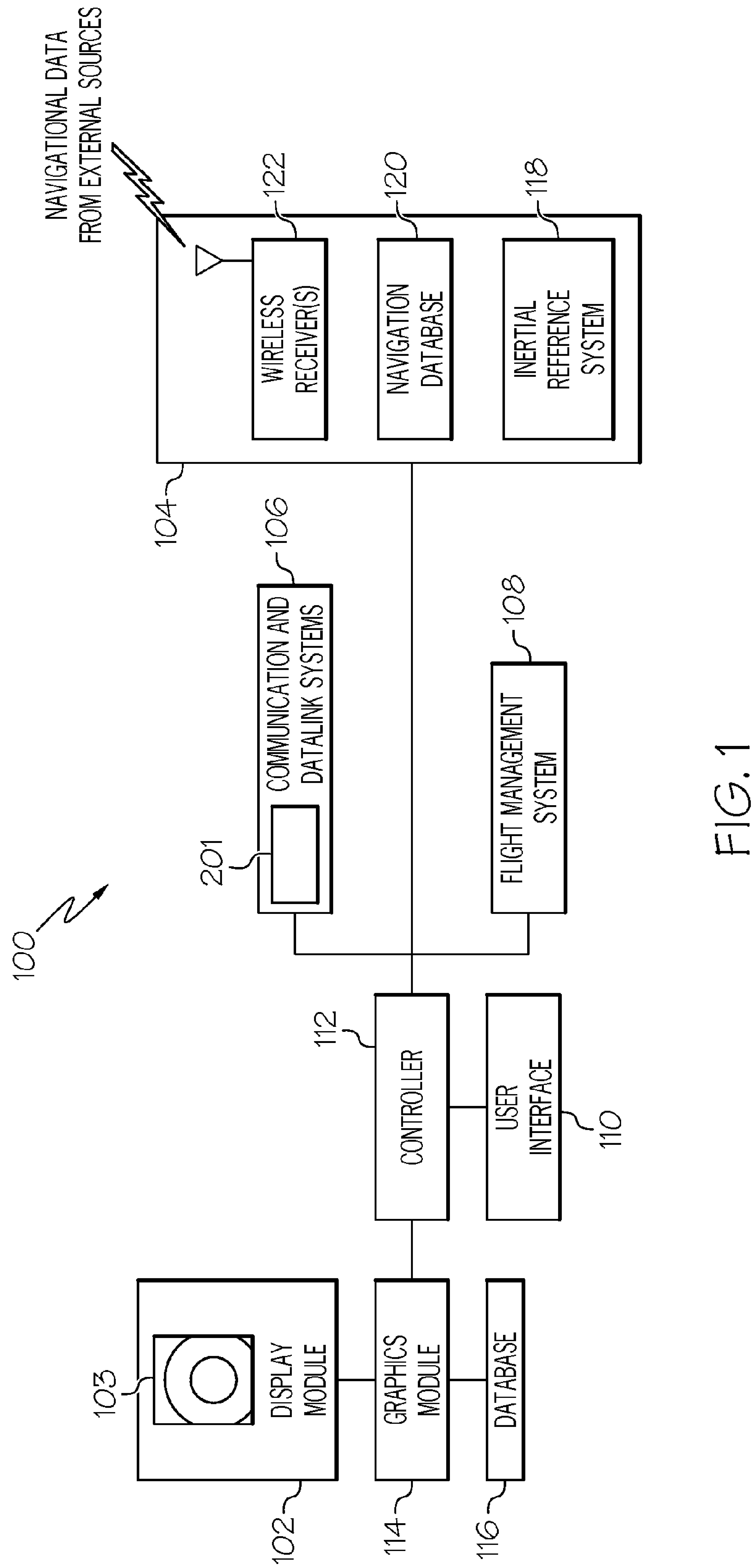

NAVIGATIONAL DATA
FROM EXTERNAL SOURCES
122
120
118
WIRELESS
RECEIVER(S)
NAVIGATION
DATABASE
INERTIAL
REFERENCE
SYSTEM
104
106
COMMUNICATION AND
DATALINK SYSTEMS
201
108
FLIGHT MANAGEMENT
SYSTEM
100
112
CONTROLLER
USER
INTERFACE
110
103
DISPLAY
MODULE
GRAPHICS
MODULE
DATABASE
102
114
116

FIG. 1

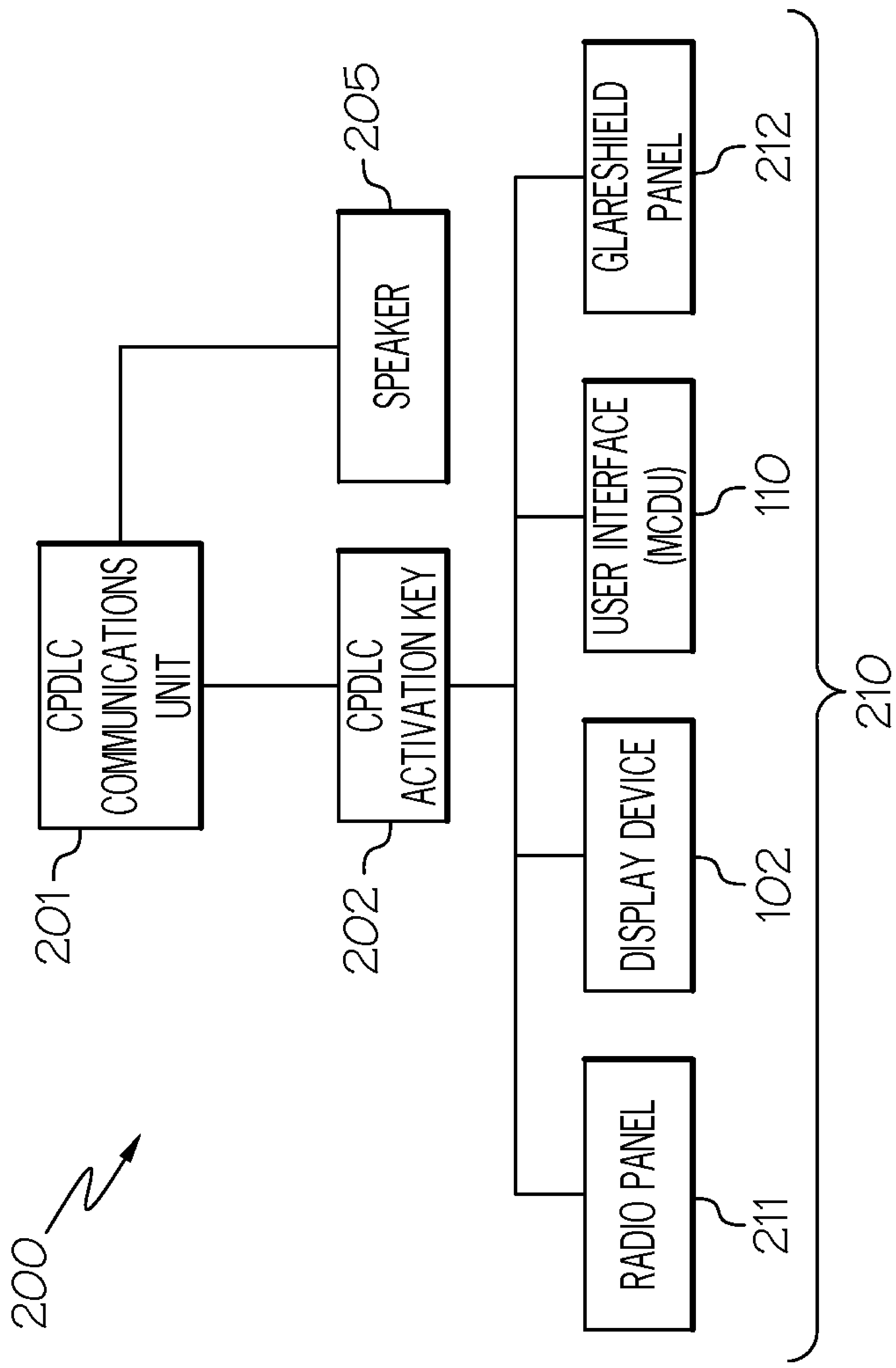

200
CPDLC COMMUNICATIONS UNIT
201
SPEAKER
205
CPDLC ACTIVATION KEY
202
RADIO PANEL
211
DISPLAY DEVICE
102
USER INTERFACE (MCDU)
110
GLARESHIELD PANEL
212
210

FIG. 2

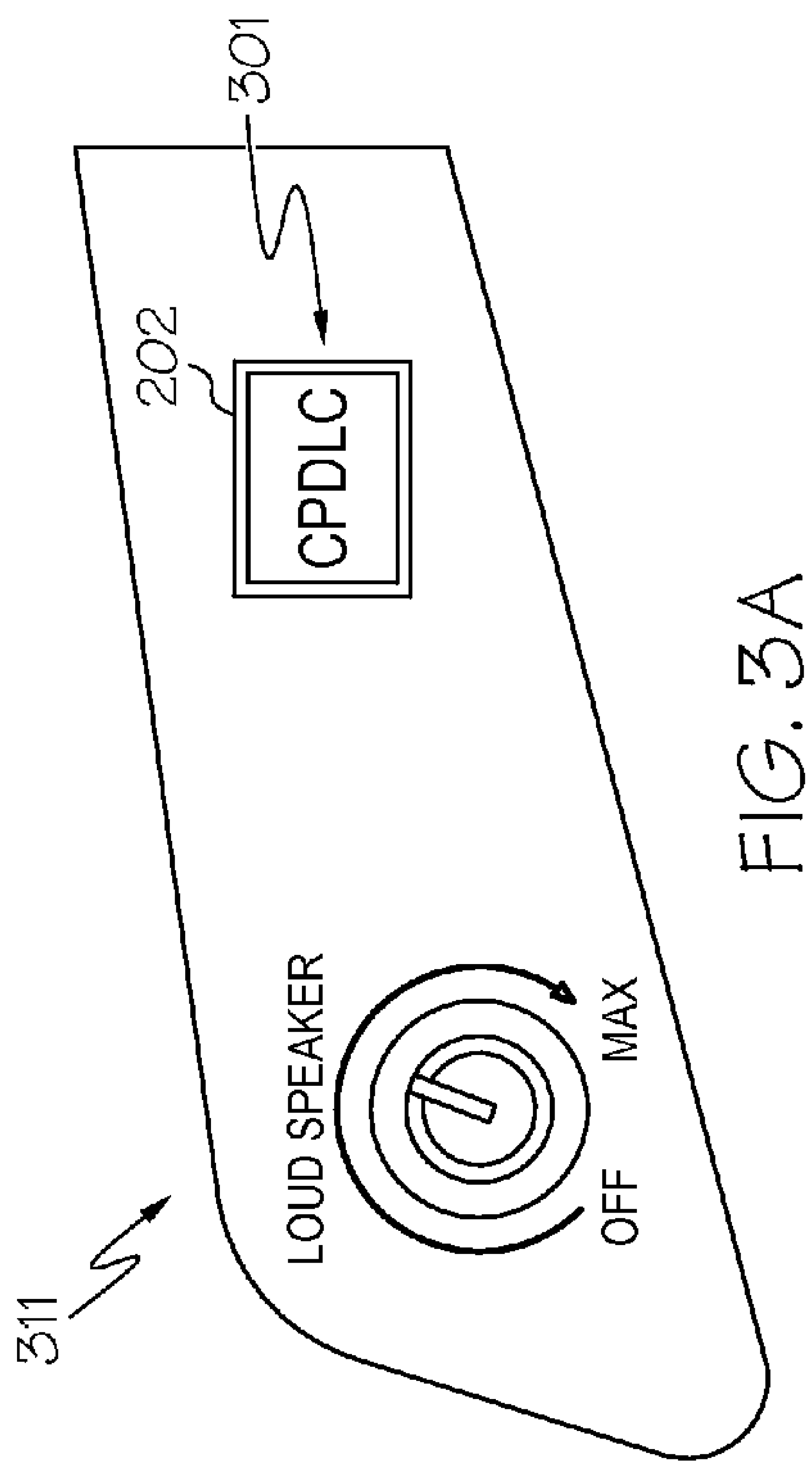

301
202
CPDLC
LOUD SPEAKER
OFF
MAX
311

FIG. 3A

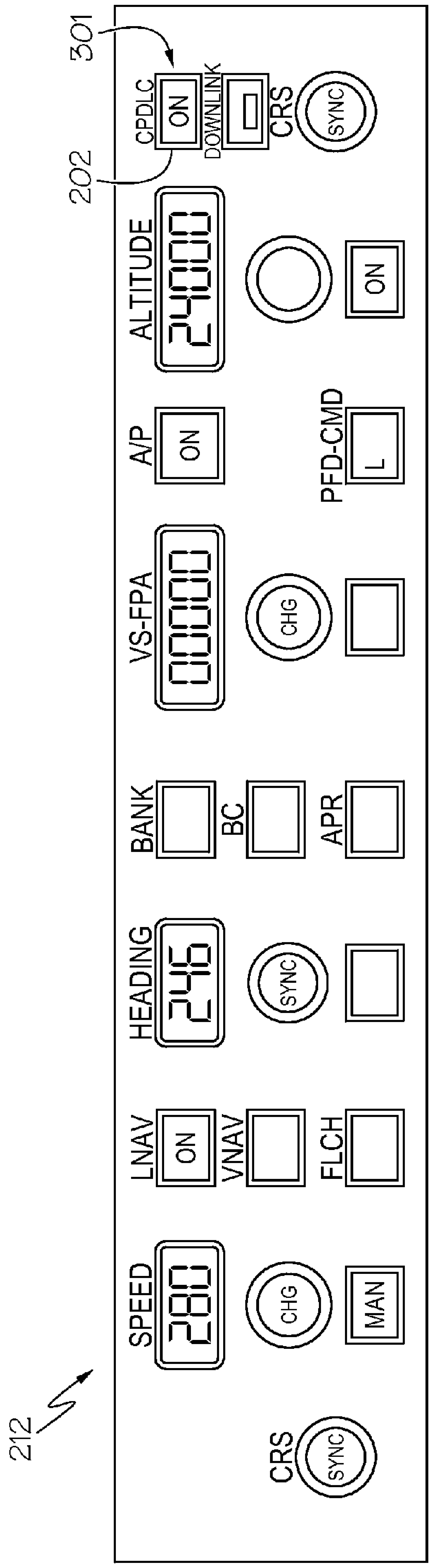

301
202
CPDLC
ON
DOWNLINK
CRS
SYNC
ALTITUDE
24000
ON
A/P
ON
PFD-CMD
L
VS-FPA
00000
CHG
BANK
BC
APR
HEADING
246
SYNC
LNAV
ON
VNAV
FLCH
SPEED
280
CHG
MAN
CRS
SYNC
212

FIG. 3D

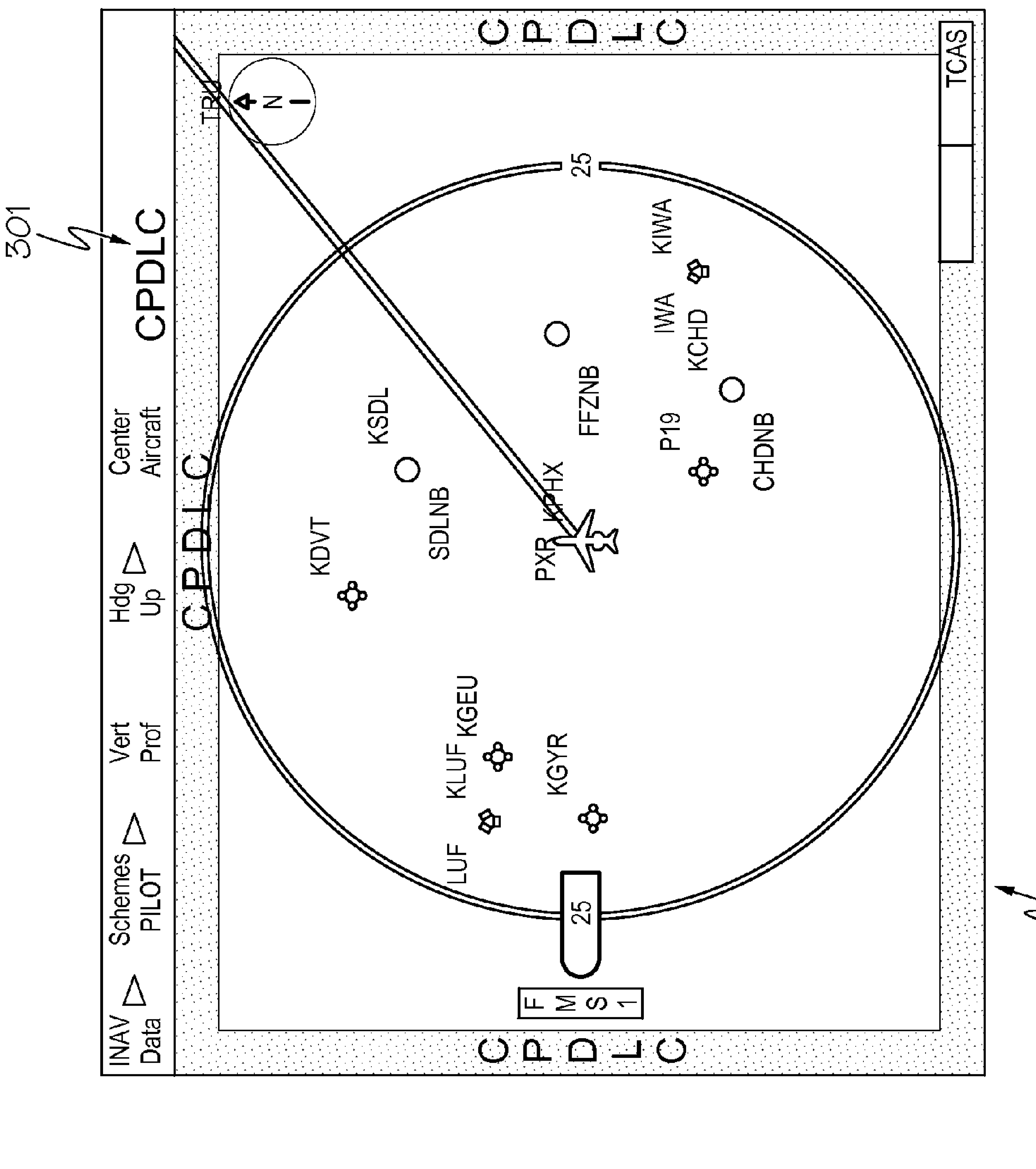
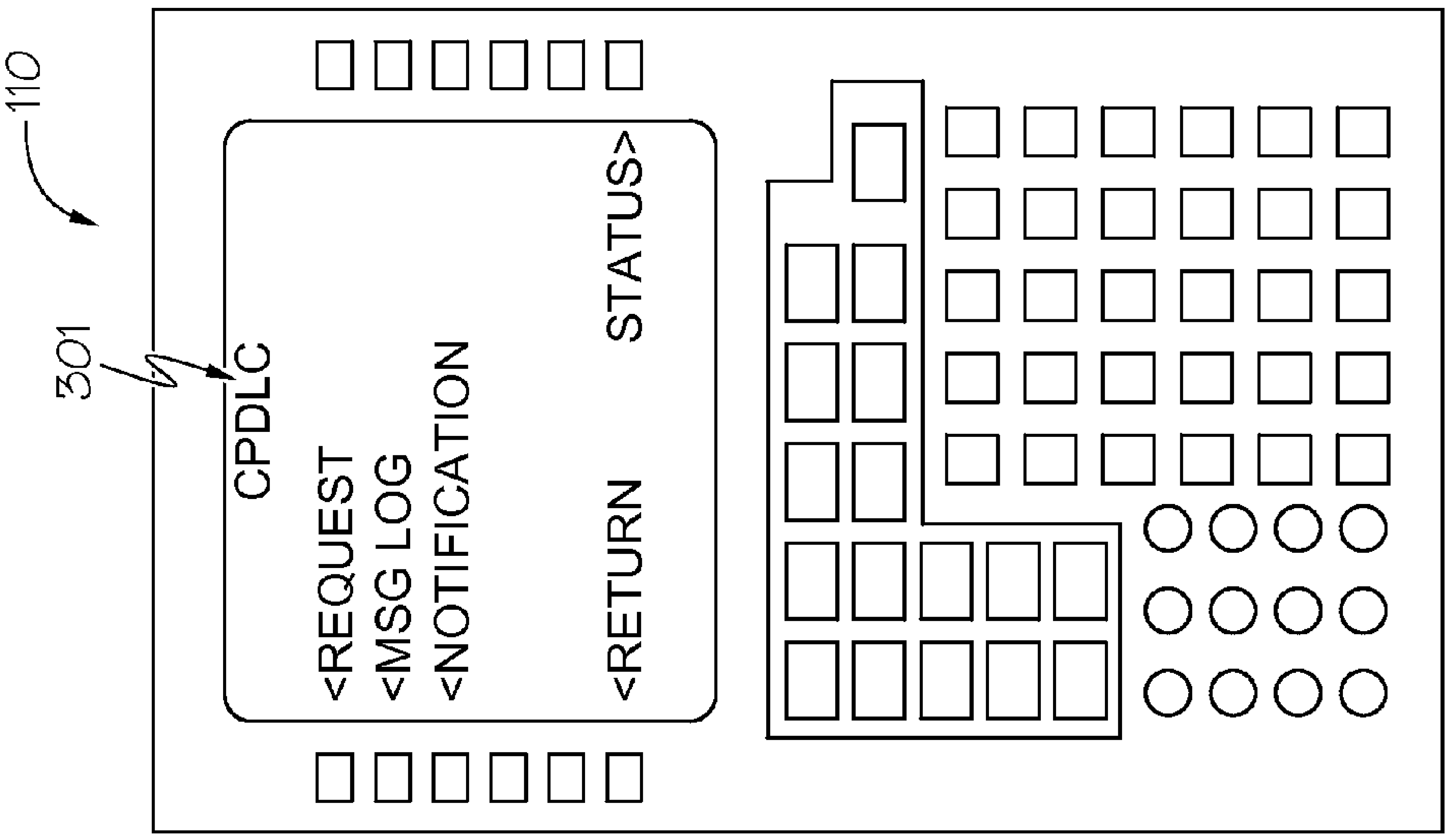

301
CPDLC
INAV Data
Schemes PILOT
Vert Prof
Hdg Up
Center Aircraft
CPDLC
CPDLC
CPDLC
TCAS
25
25
FMS 1
KDVT
KSDL
SDLNB
PXR
KPHX
FFZNB
IWA
KIWA
KCHD
P19
CHDNB
KGEU
KLUF
KGYR
LUF
102

FIG. 3B


110
301
CPDLC
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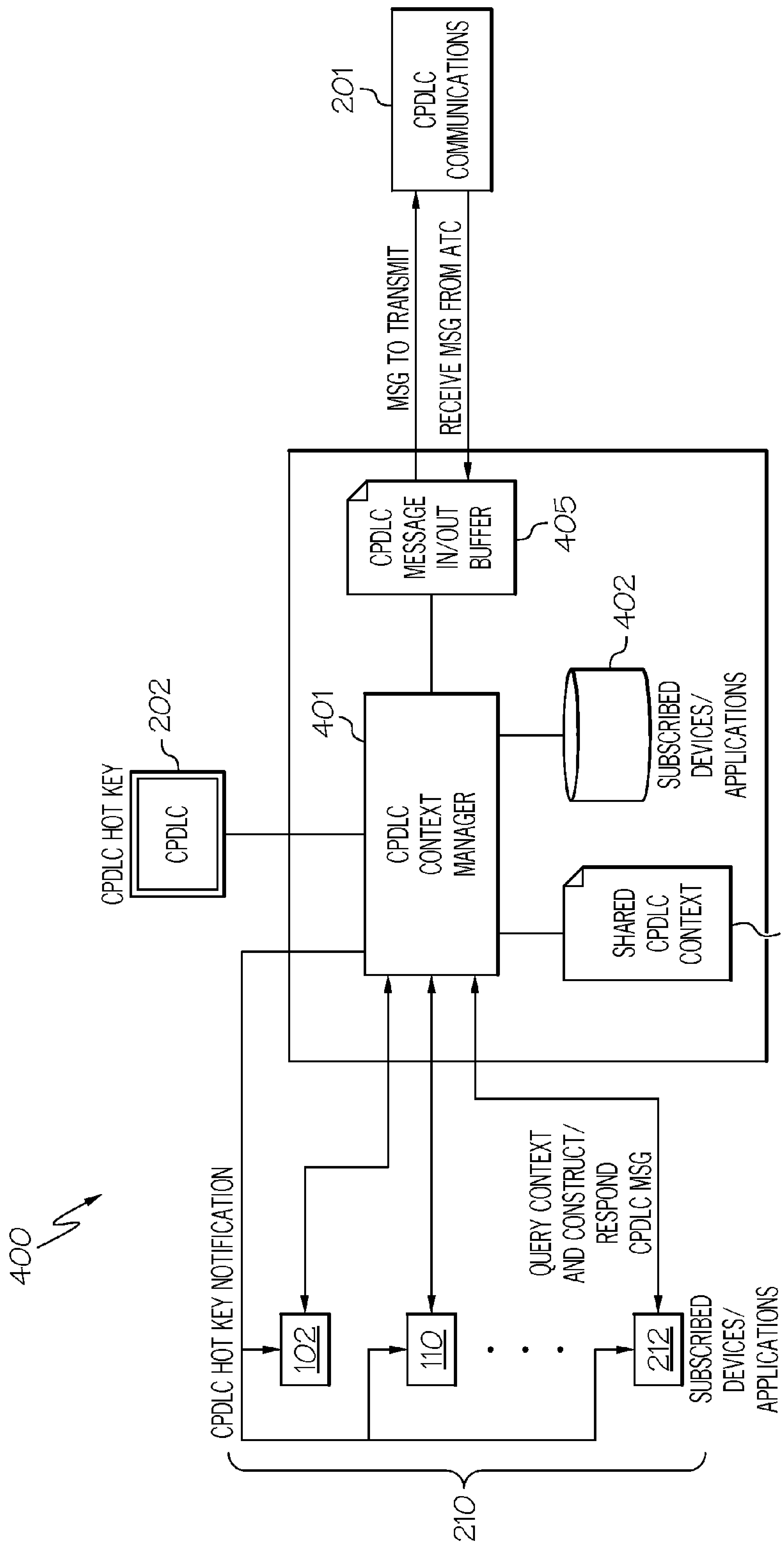
<MSG LOG
<NOTIFICATION
<RETURN
STATUS>

FIG. 3C



400
CPDLC COMMUNICATIONS
201
MSG TO TRANSMIT
RECEIVE MSG FROM ATC
CPDLC MESSAGE IN/OUT BUFFER
405
CPDLC HOT KEY
CPDLC
202
401
CPDLC CONTEXT MANAGER
402
SUBSCRIBED DEVICES/ APPLICATIONS
SHARED CPDLC CONTEXT
403
CPDLC HOT KEY NOTIFICATION
QUERY CONTEXT AND CONSTRUCT/ RESPOND CPDLC MSG
102
110
212
SUBSCRIBED DEVICES/ APPLICATIONS
210

FIG. 4

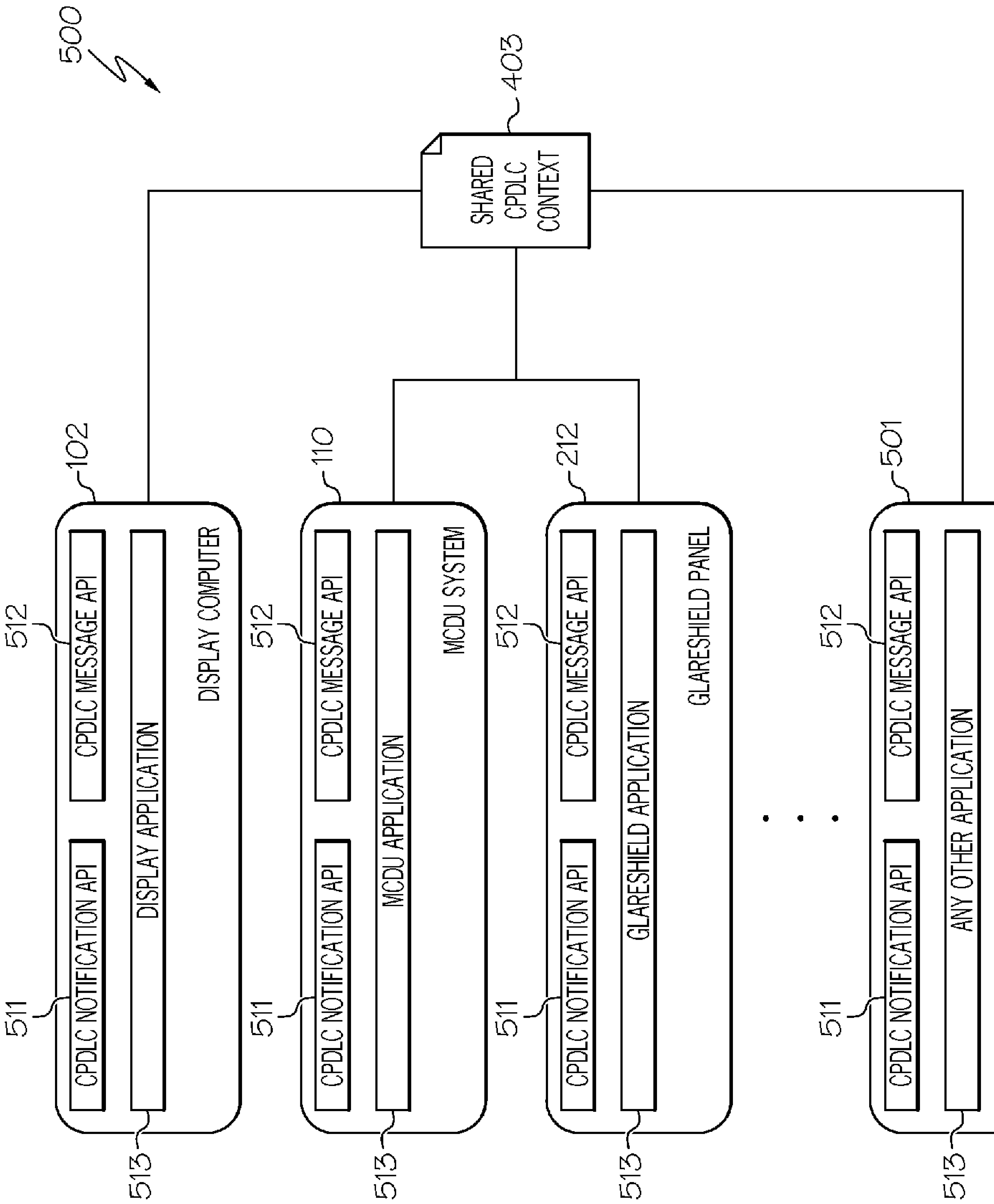

500
403
SHARED CPDLC CONTEXT
102
DISPLAY COMPUTER
CPDLC MESSAGE API
CPDLC NOTIFICATION API
DISPLAY APPLICATION
110
MCDU SYSTEM
MCDU APPLICATION
212
GLARESHIELD PANEL
GLARESHIELD APPLICATION
501
AVIONICS APPLICATION
ANY OTHER APPLICATION
511
512
513

FIG. 5

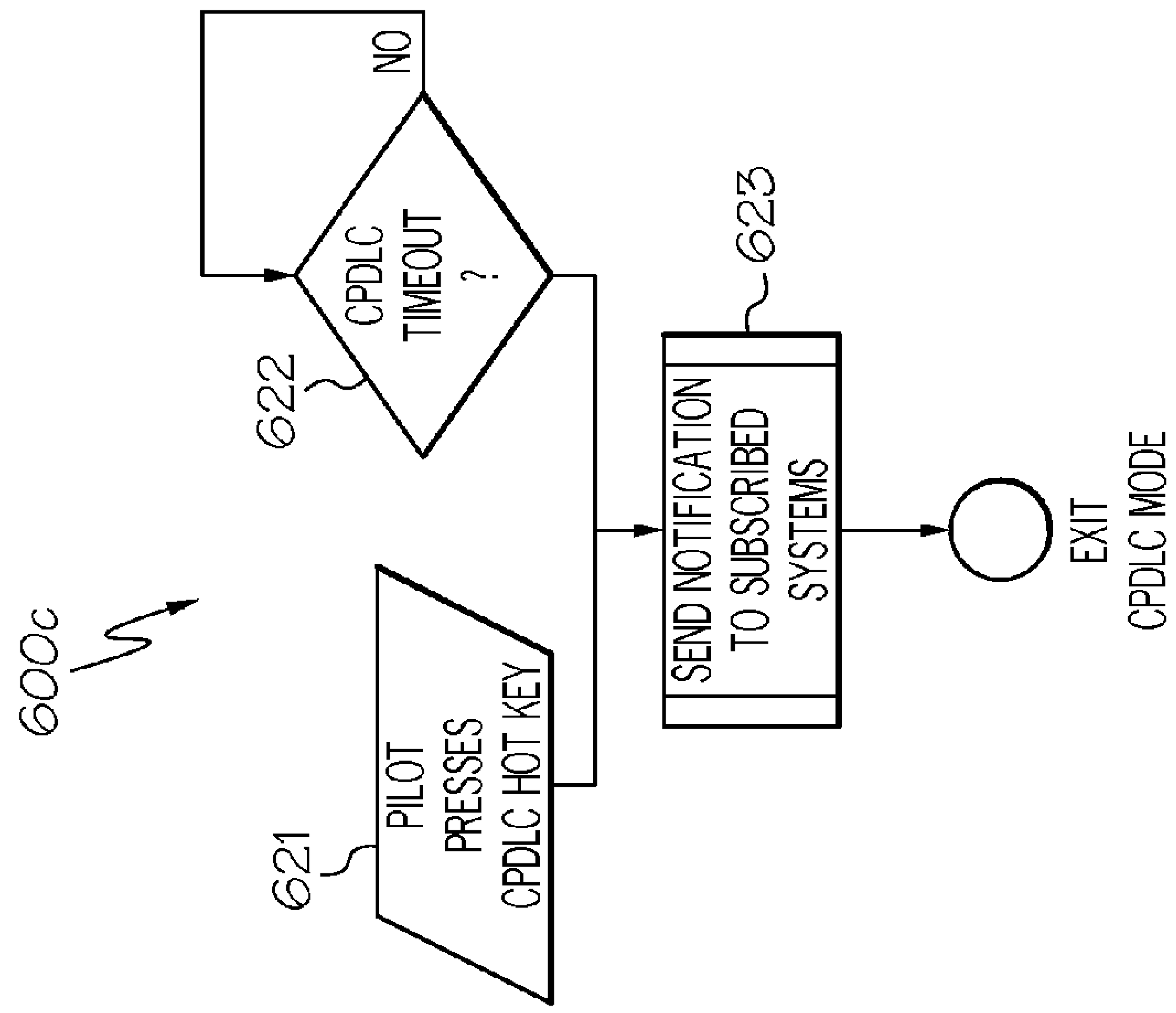


FIG. 6C

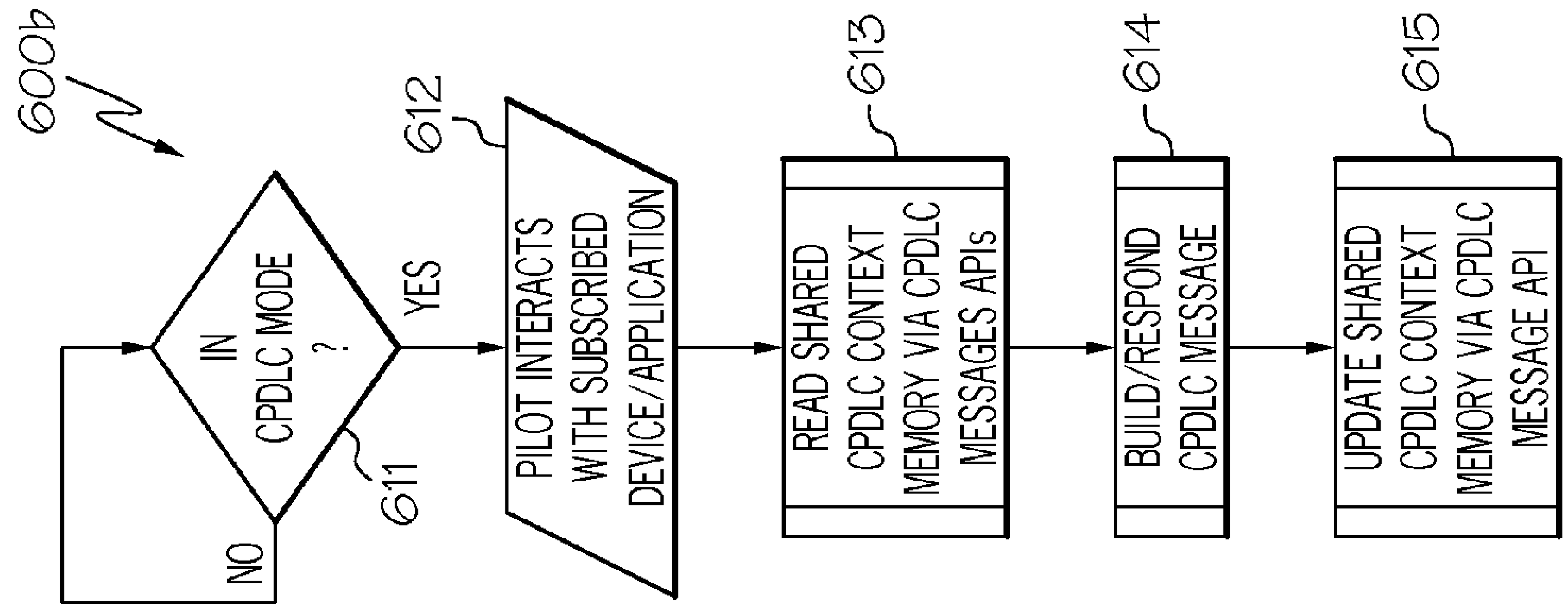


FIG. 6B

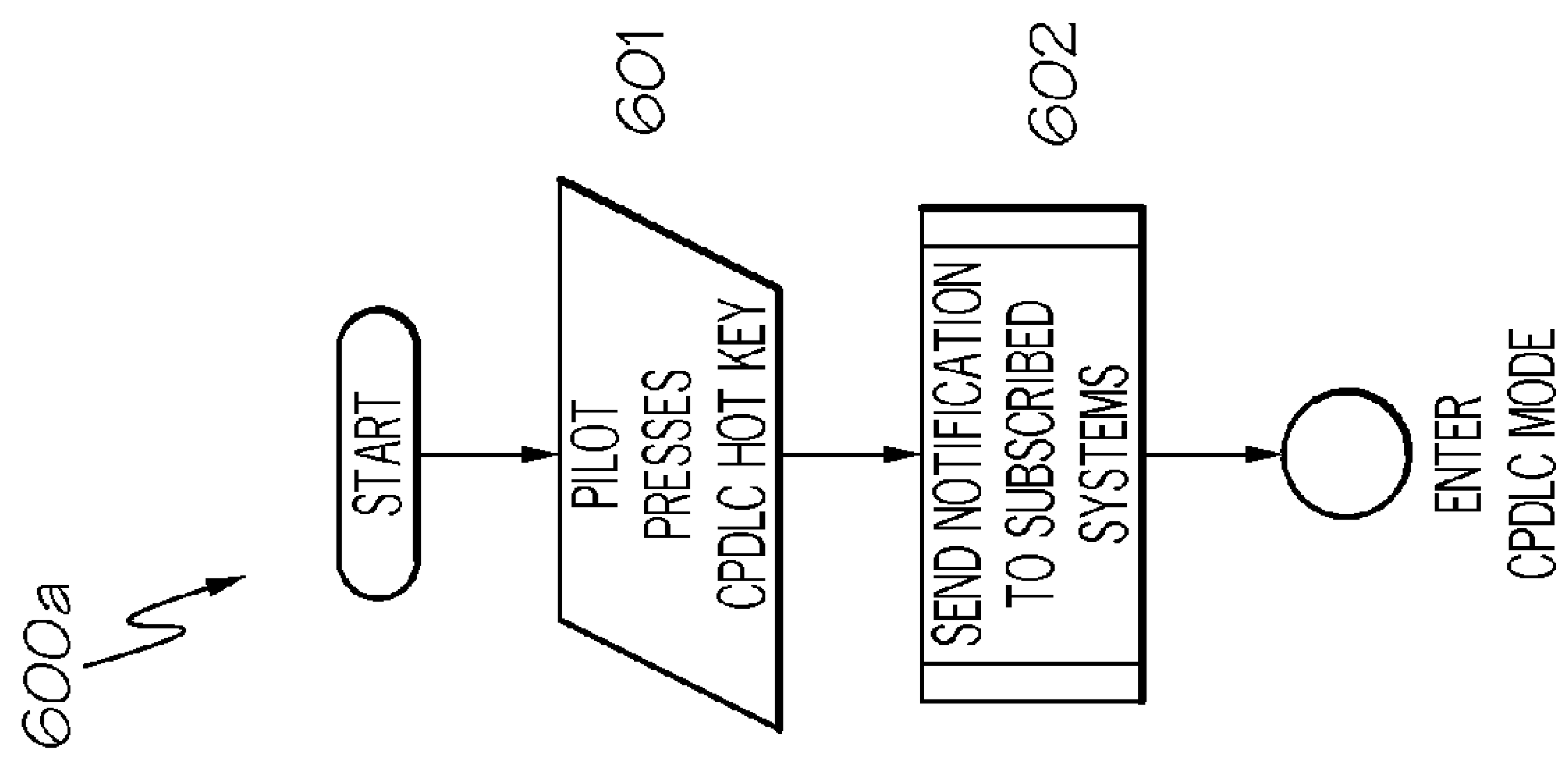


FIG. 6A

INTEGRATED CONTROLLER-PILOT DATALINK COMMUNICATION SYSTEMS AND METHODS FOR OPERATING THE SAME

TECHNICAL FIELD

Embodiments of the subject matter described herein relate generally to aircraft display systems and methods of operating aircraft display systems. More particularly, embodiments of the subject matter described herein relate to integrated controller-pilot datalink communication systems and methods for operating the same.

BACKGROUND

The standard method of communication between an air traffic controller and a pilot of an aircraft is voice radio, using either VHF bands for line-of-sight communication or HF bands for long-distance communication. One of the major problems with voice radio communications used in this manner is that all pilots being handled by a particular controller are tuned to the same frequency. As the number of flights air traffic controllers must handle is steadily increasing, the number of pilots tuned to a particular station also increases. This increases the chances that one pilot will accidentally override another, thus requiring the transmission to be repeated. In addition, each exchange between a controller and pilot requires a certain amount of time to complete; eventually, as the number of flights being controlled reaches a saturation point, the controller will not be able to handle any further aircraft. Thus, a new strategy is needed to cope with increased demands on air traffic control, and data link based communications offers a possible strategy by increasing the effective capacity of the communications channel.

Controller-pilot data link communication (CPDLC) is a means of communication between controller and pilot, using data link for air traffic control (ATC) communication. The CPDLC application provides air-ground data communication for the ATC service. This includes a set of clearance/information/request message elements that correspond to voice phraseology employed by air traffic control procedures. The controller is provided with the capability to issue flight level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The pilot is provided with the capability to respond to messages, to request clearances and information, to report information, and to declare/rescind an emergency. The pilot is, in addition, provided with the capability to request conditional clearances (downstream) and information from a downstream air traffic service unit (ATSU). A "free text" capability is also provided to exchange information not conforming to defined formats. An auxiliary capability is provided to allow a ground system to use data link to forward a CPDLC message to another ground system.

With CPDLC, there is increased communication between ATC and the pilot via text, and thus reduced communication over VHF or HF. As more applications are developed for CPDLC, the CPDLC operations can be performed from various applications or devices connected to the onboard avionics. For example, current CPDLC operations can be performed from the multifunction control display unit (MCDU), forward looking displays, and the guidance panel, among others as are known in the art. With existing avionics architectures and setups, the entire CPDLC operation has to

be performed on one of the aforesaid avionics devices/applications. That is, the pilot does not have a choice to choose the best modality in constructing or acknowledging a CPDLC message. Each modality (knob turn/button press/cursor move and click/touch) have their own advantages and disadvantages. As such, current CPDLC-enabled avionics systems are not "integrated" in the sense that they are not able to cooperate with one another to allow the pilot to select the best system(s) to construct or respond to a CPDLC message.

Accordingly, it would be desirable to provide systems and methods that enable an aircraft pilot greater freedom of choice in constructing or responding to CPDLC messages using one or more CPDLC-enabled avionics systems most suitable for a given CPDLC context. Moreover, it would be desirable to provide systems and methods that reduce pilot workload and response time in constructing or responding to CPDLC messages. Furthermore, other desirable features and characteristics of the exemplary embodiments will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and the foregoing technical field and background.

BRIEF SUMMARY

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description section. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

Integrated controller-pilot datalink communication (CPDLC) systems and methods for operating the same are disclosed. In one exemplary embodiment, an integrated CPDLC system includes a plurality of CPDLC-enabled avionics devices and a CPDLC context manager coupled with each of the plurality of CPDLC-enabled avionics devices. The CPDLC system further includes a shared CPDLC context memory coupled with the CPDLC context manager and a CPDLC message in/out buffer coupled with the CPDLC context manager.

In another exemplary embodiment, a method for operating an integrated CPDLC system includes the steps of activating a CPDLC mode in each of a plurality of CPDLC-enabled avionics devices and constructing a CPDLC message using one or more of the CPDLC-enabled avionics devices. The method further includes communicating the CPDLC message to a CPDLC communications unit using a CPDLC context manager.

In yet another exemplary embodiment, a method for operating an integrated CPDLC system includes the steps of receiving a CPDLC message at a CPDLC communications unit and activating a CPDLC mode in one or more of a plurality of CPDLC-enabled avionics devices using a CPDLC context manager. The method further includes displaying the CPDLC message on each of the one or more of the plurality of CPDLC-enabled avionics devices.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the subject matter may be derived from the following detailed description taken in conjunction with the accompanying drawings, wherein like reference numerals denote like elements, and wherein:

FIG. **1** depicts an exemplary embodiment of an aircraft display system in accordance with embodiments of the present disclosure;

FIG. **2** depicts an integrated, context-aware CPDLC system in accordance with embodiments of the presented disclosure;

FIGS. **3**A-**3**D depict various subscribed avionics devices/applications in an integrated, context-aware CPDLC mode of operation in accordance with embodiments of the present disclosure;

FIG. **4** provides an exemplary CPDLC context notification and messaging architecture in accordance with embodiments of the present disclosure;

FIG. **5** provides a general processing architecture for performing various CPDLC operations in accordance with embodiments of the present disclosure; and

FIGS. **6**A-**6**C provide methods for operating the integrated, context-aware CPDLC system in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

The following Detailed Description is merely exemplary in nature and is not intended to limit the embodiments of the subject matter or the application and uses of such embodiments. As used herein, the word "exemplary" means "serving as an example, instance, or illustration." Any implementation described herein as exemplary is not necessarily to be construed as preferred or advantageous over any other implementations. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding Technical Field, Background, Brief Summary, or the following Detailed Description.

Techniques and technologies may be described herein in terms of functional and/or logical block components and with reference to symbolic representations of operations, processing tasks, and functions that may be performed by various computing components or devices. Such operations, tasks, and functions are sometimes referred to as being computer-executed, computerized, software-implemented, or computer-implemented. In practice, one or more processor devices can carry out the described operations, tasks, and functions by manipulating electrical signals representing data bits at memory locations in the system memory, as well as other processing of signals. The memory locations where data bits are maintained are physical locations that have particular electrical, magnetic, optical, or organic properties corresponding to the data bits. It should be appreciated that the various block components shown in the figures may be realized by any number of hardware, software, and/or firmware components configured to perform the specified functions. For example, an embodiment of a system or a component may employ various integrated circuit components, e.g., memory elements, digital signal processing elements, logic elements, look-up tables, or the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices.

The following descriptions may refer to elements or nodes or features being "coupled" together. As used herein, unless expressly stated otherwise, "coupled" means that one element/node/feature is directly or indirectly joined to (or directly or indirectly communicates with) another element/node/feature, and not necessarily mechanically. Thus, although the drawings may depict one exemplary arrangement of elements, additional intervening elements, devices, features, or components may be present in an embodiment of the depicted subject matter. In addition, certain terminology may also be used in the following description for the purpose of reference only, and thus are not intended to be limiting.

For the sake of brevity, conventional techniques related to graphics and image processing, navigation, flight planning, aircraft controls, and other functional aspects of the systems (and the individual operating components of the systems) may not be described in detail herein. Furthermore, the connecting lines shown in the various figures contained herein are intended to represent exemplary functional relationships and/or physical couplings between the various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in an embodiment of the subject matter.

FIG. **1** depicts an exemplary embodiment of an aircraft display system **100**. In an exemplary embodiment, the display system **100** includes, without limitation, a display device/module **102** for displaying a graphical flight plan image **103**, a navigation system **104**, a communications and datalink system **106**, a flight management system (FMS) **108**, a controller **112**, a graphics module **114**, a user interface **110**, and a database **116** suitably configured to support operation of the graphics module **114** and display device **102**, as described in greater detail below. Navigation system **104** may include an inertial reference system **118**, a navigation database **120**, and one or more wireless receivers **122** for receiving navigational data from external sources in a well-known manner.

It should be understood that FIG. **1** is a simplified representation of a display system **100** for purposes of explanation and ease of description and is not intended to limit the application or scope of the subject matter in any way. In practice, the display system **100** and/or the aircraft will include numerous other devices and components for providing additional functions and features, as will be appreciated in the art. For example, the display system **100** and/or the aircraft may include one or more avionics systems (e.g., a weather system, an air traffic management system, a radar system, a traffic avoidance system) coupled to the flight management system **108** and/or the controller **112** for obtaining and/or providing real-time flight-related information that may be displayed on the display device **102**.

In an exemplary embodiment, the display device **102** is coupled to the graphics module **114**. The graphics module **114** is coupled to the processing controller **112**, and the processing controller **112** and the graphics module **114** are cooperatively configured to display, render, or otherwise convey graphical representations or images on the display device **102**. As stated previously, navigational system **104** includes an inertial reference system **118**, a navigation database **120**, and at least one wireless receiver **122**. Inertial reference system **118** and wireless receiver **122** provide controller **112** with navigational information derived from sources onboard and external to the host aircraft, respectively. More specifically, inertial reference system **118** provides controller **112** with information describing various flight parameters of the host aircraft (e.g., position, orientation, velocity, etc.) as monitored by a number of motion sensors (e.g., accelerometers, gyroscopes, etc.) deployed onboard the aircraft. By comparison, and as indicated in FIG. **1**, wireless receiver **122** receives navigational information from various sources external to the aircraft. These sources may include various types of navigational aids (e.g., global position systems, non-directional radio beacons, very high frequency omni-directional radio range devices (VORs), etc.), ground-based navigational facilities (e.g., Air Traffic Control Centers, Terminal Radar Approach Control

Facilities, Flight Service Stations, and control towers), and ground-based guidance systems (e.g., instrument landing systems). In certain instances, wireless receiver **122** may also periodically receive Automatic Dependent Surveillance-Broadcast (ADS-B) data from neighboring aircraft. In a specific implementation, wireless receiver **122** assumes the form of a multi-mode receiver (MMR) having global navigational satellite system capabilities.

Navigation database **120** includes various types of navigation-related data stored therein. In a preferred embodiment, navigation database **120** is an onboard database that is carried by the aircraft. The navigation-related data includes various flight plan related data such as, for example, and without limitation: locational data for geographical waypoints; distances between waypoints; track between waypoints; data related to different airports; navigational aids; obstructions; special use airspace; political boundaries; communication frequencies; and aircraft approach information.

Controller **112** is coupled to the navigation system **104** for obtaining real-time navigational data and/or information regarding operation of the aircraft to support operation of the display system **100**. In an exemplary embodiment, the communications and datalink system **106** is coupled to the controller **112** and configured to support communications to and/or from the aircraft, as is appreciated in the art. The controller **112** is also coupled to the flight management system **108**, which in turn, may also be coupled to the navigation system **104** and the communications and datalink system **106** for providing real-time data and/or information regarding operation of the aircraft to the controller **112** to support operation of the aircraft. In an exemplary embodiment, the user interface **110** is coupled to the controller **112**, and the user interface **110** and the controller **112** are cooperatively configured to allow a user to interact with display device **102** and other elements of display system **100**, as described in greater detail below.

In an exemplary embodiment, the display device **102** is realized as an electronic display configured to graphically display flight information or other data associated with operation of the aircraft under control of the graphics module **114**. In an exemplary embodiment, the display device **102** is located within a cockpit of the aircraft. It will be appreciated that although FIG. **1** shows a single display device **102**, in practice, additional display devices may be present onboard the aircraft. In an exemplary embodiment, the user interface **110** is also located within the cockpit of the aircraft and adapted to allow a user (e.g., pilot, co-pilot, or crew member) to interact with the remainder of display system **100** and enables a user to select content displayed on the display device **102**, as described in greater detail below. In various embodiments, the user interface **110** may be realized as a keypad, touchpad, keyboard, mouse, touchscreen, joystick, knob, microphone, or another suitable device adapted to receive input from a user. In preferred embodiments, user interface **110** may be a touchscreen, cursor control device, joystick, or the like.

In an exemplary embodiment, the navigation system **104** is configured to obtain one or more navigational parameters associated with operation of the aircraft. The navigation system **104** may be realized as a global positioning system (GPS), inertial reference system (IRS), or a radio-based navigation system (e.g., VHF Omni-directional radio range (VOR) or long range aid to navigation (LORAN)), and may include one or more navigational radios or other sensors suitably configured to support operation of the navigation system **104**, as will be appreciated in the art. In an exemplary embodiment, the navigation system **104** is capable of obtaining and/or determining the instantaneous position of the aircraft, that is, the current location of the aircraft (e.g., the latitude and longitude) and the altitude or above ground level for the aircraft. The navigation system **104** may also obtain and/or determine the heading of the aircraft (i.e., the direction the aircraft is traveling in relative to some reference).

In an exemplary embodiment, the communications and datalink system **106** is suitably configured to support communications between the aircraft and another aircraft or ground location (e.g., air traffic control) either via voice commands or data messaging. In this regard, the communications and datalink system **106** may be realized using a radio communication system or another suitable data link system. In an exemplary embodiment, the communications and datalink system **106** includes a CPDLC communications unit **201**, as will be described in greater detail below. The flight management system **108** (or, alternatively, a flight management computer) is located onboard the aircraft. Although FIG. **1** is a simplified representation of display system **100**, in practice, the flight management system **108** may be coupled to one or more additional modules or components as necessary to support navigation, flight planning, and other aircraft control functions in a conventional manner.

The controller **112** and/or graphics module **114** are configured in an exemplary embodiment to display and/or render information on the display device **102** to allow a user (e.g., via user interface **110**) to review various aspects (e.g., estimated flight time, rates of ascent/descent, flight levels and/or altitudes, and the like) of the flight plan. The controller **112** generally represents the hardware, software, and/or firmware components configured to facilitate the display and/or rendering of a navigational map on the display device **102** and perform additional tasks and/or functions described in greater detail below. Depending on the embodiment, the controller **112** may be implemented or realized with a general purpose processor, a content addressable memory, a digital signal processor, an application specific integrated circuit, a field programmable gate array, any suitable programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof, designed to perform the functions described herein. The controller **112** may also be implemented as a combination of computing devices, e.g., a combination of a digital signal processor and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a digital signal processor core, or any other such configuration. In practice, the controller **112** includes processing logic that may be configured to carry out the functions, techniques, and processing tasks associated with the operation of the display system **100**, as described in greater detail below. Furthermore, the steps of a method or algorithm described in connection with the embodiments disclosed herein may be embodied directly in hardware, in firmware, in a software module executed by the controller **112**, or in any practical combination thereof.

The graphics module **114** generally represents the hardware, software, and/or firmware components configured to control the display and/or rendering of a navigational map on the display device **102** and perform additional tasks and/or functions described in greater detail below. In an exemplary embodiment, the graphics module **114** accesses one or more databases **116** suitably configured to support operations of the graphics module **114**, as described below. In this regard, the database **116** may comprise a terrain database, a weather database, a flight plan database, an obstacle database, a navigational database, a geopolitical database, a terminal airspace database, a special use airspace database, or other information for rendering and/or displaying content on the display device **102**, as described below. It will be appreciated that although FIG. **1** shows a single database **116** for purposes of explanation and ease of description, in practice, numerous databases will likely be present in a practical embodiment of the display system **100**.

The aircraft display system described above may further include an integrated, context-aware CPDLC system **200** as shown and described with respect to FIG. **2**. The CPDLC system **200** includes CPDLC communications unit **201**. In one embodiment, the CPDLC communication unit **201** is installed on the same on-board aircraft system where the aircraft's CPDLC applications are installed. For example, in some embodiments, the physical device performing the CPDLC message processing will be the aircraft's communications and datalink system **106**, or other system executing the CPDLC application. In some embodiments, therefore, functions relating to CPDLC message processing discussed herein are implemented at least in part as a software application executing on such physical devices.

The CPDLC communications unit **201** is coupled to a speaker **205** and to a CPDLC activation key **202**, which in some embodiments may be referred to as a CPDLC "hot key." Pressing the CPDLC activation key **202** activates all subscribed avionics systems to switch to an integrated CPDLC mode. As shown in FIG. **2**, the CPDLC activation key is coupled to a plurality of CPDLC-subscribed user interface devices **210**. In non-limiting examples, these CPDLC-subscribed user interface devices **210** may include, but are not limited to, a cockpit radio panel **211**, the display device/module **102**, the user interface **110** (which in some embodiments may take the form of, or may include, an MCDU), and a glareshield panel **212**. In the prior art, each of the devices **210** described above was capable of individually functioning in a CPDLC mode. However, none of the devices **210** were capable of cooperating with one another in an integrated CPDLC context. In accordance with the present disclosure, the CPDLC activation key **202** is provided to initiate all of the devices **210** to switch their modes to the integrated, context-aware CPDLC mode of operation. For example, when the CPDLC activation key **202** is pressed by the pilot, each of the CPDLC-subscribed user interface devices **210** (e.g., the radio panel **211**, the display device **102**, the MCDU **110**, and the glareshield panel **212**) automatically switches to the CPDLC mode of operation.

The implementation and use of the CPDLC activation key **202** creates a continuity of operation for a common objective across the various subscribed avionics devices/applications **210**. FIGS. **3**A-**3**D illustrate such devices **210** after the CPDLC activation key **202** has been pressed by the pilot. FIGS. **3**A and **3**D further illustrate various implementations of the CPDLC activation key **202**. For example, in FIG. **3**A, a portion of an exemplary dedicated panel **311** is illustrated. The dedicated panel **311** is an example of a location where the CPDLC activation key **202** may be implemented, as shown. The dedicated panel **311** includes an indication **301** of when the integrated, context-aware CPDLC mode has been activated, for example by pressing the CPDLC activation key **202** thereon. In this example, the indication **301** is the illumination of the letters "CPDLC" on the activation key **202**, as shown. In a further example, in FIG. **3**B, the display device **102** includes the indication **301** in the form of the letters "CPDLC" being superimposed over the display, for example on one of more of a top portion or side portion of the display, as shown. In a further example, in FIG. **3**C, the MCDU **110** includes the indication **301** located above the text portions of the MCDU display in the form of the letters "CPDLC" being printed thereon. It will also be appreciated that, although not illustrated, the CPDLC mode may be activated through the MDCU **110** by browsing to the CPDLC page and selecting a CPDLC activation button (e.g., similar in function to key **202**). In yet a further example, in FIG. **3**D, a portion of an exemplary glareshield panel **212** is illustrated. The glareshield panel **212** is an example of a location where the CPDLC activation key **202** may be implemented, as shown. The glareshield panel **212** includes the indication **301**, which again may include the illumination of the letters "CPDLC" upon pressing of the CPDLC activation key **202**. In any of the embodiments described above, pressing the CPDLC activation key **202** activates all subscribed avionics systems **210** to switch to the CPDLC mode. In this regard, for example, the MCDU **110** shows the CPDLC page ready to take pilot input and/or show ATC communications, the display device **102** goes into CPDLC mode (or activates CPDLC pages thereon), and the glareshield panel **212** switches to CPDLC mode as well.

With reference now to FIG. **4**, which provides an exemplary CPDLC context notification and messaging architecture **400**, when the CPDLC activation key **202** is pressed, the event is registered in a CPDLC context manager **401**. The CPDLC context manager **401** sends out the notification to the devices/applications **210** that are subscribed to the CPDLC by looking up a subscribed devices database or lookup table **402** in non-volatile memory. These subscribed devices **210** now switch to the CPDLC mode of operation. All of the subscribed devices **210** are now able to create or respond to a CPDLC message. This is possible because the CPDLC context manager **401** grants access to the subscribers **210** to read/write data into a shared CPDLC context memory **403**. Based on the context and usability needs, each device/application assists in partial or complete construction/response to the CPDLC message.

For example, the notification and messaging architecture **400** may be employed to respond to an ATC message in the following manner. Once the complete message is available in the shared CPDLC context memory **403**, the CPDLC context manager **401** copies the message to CPDLC message in/out buffer **405**, which is then transmitted to the CPDLC communications unit **201** for further processing. In another example, the notification and messaging architecture **400** may be employed to receive an ATC message in the following manner. When the communications unit **201** receives a new CPDLC message from ATC, it transmits the newly-received CPDLC message to the CPDLC message in/out buffer **405** and notifies the CPDLC context manager **401**. The CPDLC context manager **401** notifies all the subscribers **210** via the CPDLC messaging architecture **400**. Each of the subscribers **400** decodes the received CPDLC message and switches to the CPDLC mode of operation. If a specific CPDLC message is not applicable to a subscriber, the subscriber ignores the message. For example, if the CPDLC message is: "CLIMB TO FL200 AND MAINTAIN ALTITUDE," the display device **102**, MCDU **110**, and glareshield **212** may switch to CPDLC mode of operation while the radio panel **211** may not do so. Alternately, the context manager **401** may parse the received CPDLC message and notify relevant/applicable subscribers individually, which will then switch to the CPDLC mode.

Accordingly, once in the CPDLC mode, any of the subscribed devices **210** may be used for CPDLC communications. For example, in operation, CPDLC communications unit **201** receives a CPDLC uplink including one or more individual message elements. For each message element, the CPDLC communications unit **201** along with CPDLC context manager **401** extracts a message element ID and generates a series of displays or other outputs for displaying their corresponding messages and prompting a valid response via subscribed avionics devices **210**. Optionally, extracted message elements ID(s) can be used to populate a table that includes information and attributes such as, but not limited to the priority, alert level and response type for each element, these attributes may activate features and functions in subscribed avionics devices **210**.

In one embodiment, CPDLC context manager **401** may operate to display messages to the pilot, and prompts for valid responses, using any of the subscribed avionics devices **210**. For example, using the example shown in FIG. **3**B of the display device **102** being subscribed, the display device **102** enters CPDLC mode and the pilot may enter a request or respond to a request. When a flight crew member decides to initiate/respond to a CPDLC uplink, CPDLC context manager **401** utilizes extracted elements IDs to bring up specific display screens onto display device **102**. Those specific display screens are presented to the flight crew user, one at a time, via display device **102**.

FIG. **5** provides a general processing architecture for a subscriber CPDLC device/application to read/write onto the shared CPDLC context memory **403**, receive the CPDLC activation key **202** notification, and receive/respond to messages from CPDLC context manager **401**. As shown, each of the subscribed devices **210** (e.g., display device **102**, MCDU **110**, and other avionics application **501**) includes both a CPDLC notification application programming interface (API) **511** and a CPDLC message API **512**, collectively coupled with the shared CPDLC context memory **403**. The API **511** is provided for receiving the CPDLC activation key **202** notification, and the API **512** is provided for receiving/responding to messages from the CPDLC context manager **401**. Each application **513** of the subscribed devices **210** may accordingly read/write to the CPDLC context memory **403**.

FIGS. **6**A-**6**C provide methods for operating the integrated, context-aware CPDLC system in accordance with embodiments of the present disclosure. More particularly, FIGS. **6**A-**6**C show the process flow from the time of entry into CPDLC mode to the time of exit from CPDLC mode. With reference first to FIG. **6**A, which illustrates an exemplary CPDLC mode entry process **600***a*, once the crew presses the CPDLC activation key **202** (step **601**), a notification is sent to the CPDLC subscribed devices **210** by the CPDLC context manager **401** (step **602**). With reference next to FIG. **6**B, which illustrates an exemplary CPDLC mode messaging process **600***b*, once the device switches to CPDLC mode of operation (determination made at step **611**), the crew can make a CPDLC request or respond to an ATC communication (step **612**). Based on the operation performed on one of the devices/applications **210** (for example dialing of altitude FL200 on the glareshield panel **212**), the display device **102** and the MCDU **110** is notified of the dialed altitude from the shared CPDLC context memory **403** via the CPDLC messaging API **512** (step **613**). The "Request Altitude FL200" is displayed on the scratch pad on the MCDU **110** and the display area on the display device **102**. The crew is now able to review/edit the message either on MCDU **110** or display device **102** (step **614**), and hit a line select key on MCDU **110** or click a button on another device to downlink the CPDLC message to the ATC (step **615**). With reference now to FIG. **6**C, which illustrates an exemplary CPDLC mode exit process **600***c*, once the process **600***b* is performed, the pilot can select the CPDLC activation key **202** (step **621**), to exit the CPDLC mode. Alternately, with a predetermined time threshold, the CPDLC mode is automatically exited out (step **622**). Thereafter, the CPDLC context manager sends a notification to the subscribed avionics systems **210** to exit CPDLC mode (step **623**). When the CPDLC mode disengages or times-out, the previous guidance panel or display settings are then re-established. In the illustrative example of the MCDU **110**, once the CPDLC mode is disengaged, the MCDU **110** should revert to the previous altitude displayed in the altitude window thereof.

Illustrative Examples

The present disclosure is now illustrated by the following non-limiting examples. It should be noted that various changes and modifications can be applied to the following examples and processes without departing from the scope of this invention, which is defined in the appended claims. Therefore, it should be noted that the following examples should be interpreted as illustrative only and not limiting in any sense.

Example 1: Pilot Requests Climb to 50,000 ft. at Waypoint GUP

Step 1: Push CPDLC activation key **202**

Step 2: Dial altitude knob on glareshield **212** to 50,000 ft.

Step 3: Select waypoint "GUP" on display device **102** using cursor control device or touch device (note: display device **102** automatically would have switched to CPDLC mode as it is a subscriber)

Step 4: Review the message on display device **102**

Step 5: Click "send" button on display device **102**

Step 6: Pilot disengages CPDLC mode or CPDLC mode times out

Example 2: Pilot Requests Climb to 50,000 ft. at Waypoint GUP

Step 1: Push CPDLC activation key **202**

Step 2: Select waypoint "GUP" on display device **102** using cursor control device or touch device

Step 3: Dial altitude knob on glareshield **212** to 50,000 ft.

Step 4: Review the message on MCDU **110** scratchpad (note: MCDU **110** would have automatically switched to CPDLC page and shows relevant text as it is a subscriber)

Step 5: Press "send" button line select key on MCDU **110** display

Step 6: Pilot disengages CPDLC mode or CPDLC mode times out

Step 7: MCDU **110** reverts to the previous altitude displayed in the altitude window

Example 3: ATC Requires Climb and Maintain 50,000 ft. at Waypoint GUP

Step 1: Pilot hears a chime (e.g., from speaker **205**) for new message from ATC

Step 2: Push CPDLC activation key **202**

Step 3: The display device **102** enters CPLDC mode and shows pending vertical flight plan (climbing to 50000 ft at waypoint "DAISY")

Step 4: Pilot reviews and selects WILCO button on display device **102**

Step 5: Pilot disengages CPDLC mode or CPDLC mode times out

Example 4: ATC Requires Climb and Maintain 50,000 ft. at Waypoint GUP

Step 1: Pilot hears a chime (e.g., from speaker **205**) for new message from ATC

Step 2: Push CPDLC activation key **202**

Step 3: MCDU **110** page switches to CPDLC mode and shows CPDLC message and flight plan edited for 50,000 ft. climb at waypoint "DAISY" (in edit color) and a WILCO/UNABLE option (in edit color)

Step 4: Pilot chooses the line select key next to WILCO on MCDU **110**

Step 5: Pilot disengages CPDLC mode or CPDLC mode times out

Step 6: MCDU **110** reverts to the previous altitude displayed in the altitude window

Accordingly, described herein have been embodiments that relate to integrated controller-pilot datalink communication systems and methods for operating the same. The described embodiments provide systems and methods that enable an aircraft pilot greater freedom of choice in constructing or responding to CPDLC messages using one or more CPDLC-enabled avionics systems most suitable for a given CPDLC context. Moreover, the described embodiments provide systems and methods that reduce pilot workload and response time in constructing or responding to CPDLC messages.

While at least one exemplary embodiment has been presented in the foregoing detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or embodiments described herein are not intended to limit the scope, applicability, or configuration of the claimed subject matter in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing the described embodiment or embodiments. It should be understood that various changes can be made in the function and arrangement of elements without departing from the scope defined by the claims, which includes known equivalents and foreseeable equivalents at the time of filing this patent application.

What is claimed is:

1. An integrated controller-pilot datalink communication (CPDLC) system in an aircraft comprising:

a plurality of CPDLC-enabled avionics devices of the aircraft, wherein said plurality is selected from two or more of the following:

a) a cockpit forward display device coupled to a graphics module and a graphics database,

b) a glareshield panel comprising one or more of a speed, heading, or altitude selection button,

c) a multifunction cockpit display unit (MCDU) comprising a display, a keypad, and a plurality of selection lines, wherein each CPDLC-enabled avionics device of the plurality of CPDLC-enabled avionics devices is located in a different physical location within a cockpit of the aircraft;

a CPDLC context manager coupled with each of the plurality of CPDLC-enabled avionics devices, wherein the CPDLC context manager grants two or more of the plurality of CPDLC-enabled avionics devices access to a CPDLC context memory and further directs a CPDLC message generated by two or more of the plurality of CPDLC-enabled avionics devices to a CPDLC message in/out buffer;

a CPDLC activation key coupled with CPDLC context manager, wherein the CPDLC activation key, when selected, initiates a CPDLC mode in each of the plurality of CPDLC-enabled avionics devices;

the shared CPDLC context memory coupled with the CPDLC context manager, wherein the CPDLC context manager manages the shared CPDLC context memory; and

the CPDLC message in/out buffer coupled with the CPDLC context manager and a CPDLC communications unit coupled with the CPDLC message in/out buffer that sends and receives CPDLC messages to and from ground-based air traffic control,

wherein the two or more of the plurality of CPDLC-enabled avionics devices cooperatively construct a single CPDLC message in the shared CPDLC context memory, wherein the CPDLC message comprises two components: 1) a requested speed, a requested altitude, or a requested heading, and 2) a navigational waypoint associated with component 1), wherein component 1) is indicated using a first one of two or more of the plurality of CPDLC-enabled avionics devices a)-c) and component 2) is indicated using a second one, different from the first one, of two or more of the plurality of CPDLC-enabled avionics devices a)-c), wherein cooperatively constructing comprises the first one of the two or more of the plurality of CPDLC-enabled avionics devices providing a first portion of the single CPDLC message corresponding to the requested speed, requested altitude, or requested heading, and the second one of the two or more of the plurality of CPDLC-enabled avionics devices providing a second portion of the single CPDLC message that is different from the first portion of the single CPDLC message and corresponding to the navigational waypoint associated with component 1).

2. The CPDLC system of claim **1**, wherein one of the plurality of CPDLC-enabled avionics devices comprises the cockpit forward display device coupled to a graphics module and a graphics database with a display page of the cockpit forward display device implementing the CPDLC activation key.

3. The CPDLC system of claim **1**, wherein one of the plurality of CPDLC-enabled avionics devices comprises the glareshield panel comprising one or more of a speed, heading, or altitude selection button and wherein the CPDLC activation key is implemented on the glareshield panel.

4. The CPDLC system of claim **1**, wherein one of the plurality of CPDLC-enabled avionics devices comprises the radio panel comprising a radio frequency selection functionality.

5. The CPDLC system of claim **1**, wherein one of the plurality of CPDLC-enabled avionics devices comprises the multifunction cockpit display unit (MCDU) comprising a display, a keypad, and a plurality of selection lines and wherein the CPDLC activation key is implemented on the MCDU.

6. The CPDLC system of claim **1** wherein the CPDLC context manager references a list or database of the CPDLC-enabled avionics devices.

7. A method for operating an integrated controller-pilot datalink communication (CPDLC) system in an aircraft comprising the steps of:

activating a CPDLC mode in each of a plurality of CPDLC-enabled avionics devices of the aircraft, wherein said plurality is selected from two or more of the following:

a) a cockpit forward display device coupled to a graphics module and a graphics database,

b) a glareshield panel comprising one or more of a speed, heading, or altitude selection button,

c) a multifunction cockpit display unit (MCDU) comprising a display, a keypad, and a plurality of selection lines, wherein each CPDLC-enabled avionics device of the plurality of CPDLC-enabled avionics devices is located in a different physical location within a cockpit of the aircraft;

constructing a CPDLC message using two or more of the plurality of CPDLC-enabled avionics devices, wherein the CPDLC message comprises two components: 1) a requested speed, a requested altitude, or a requested heading, and 2) a navigational waypoint associated with component 1), wherein constructing the CPDLC message comprises indicating component 1) using a first one of two or more of the plurality of CPDLC-enabled avionics devices a)-c) and indicating component 2) using a second one, different from the first one, of two or more of the plurality of CPDLC-enabled avionics devices a)-c), wherein subsequent to indicating components 1) and 2), the two or more of the plurality of CPDLC-enabled avionics devices cooperatively construct a single CPDLC message in a shared CPDLC context memory, wherein cooperatively constructing comprises the first one of the two or more of the plurality of CPDLC-enabled avionics devices providing a first portion of the single CPDLC message corresponding to the requested speed, requested altitude, or requested heading, and the second one of the two or more of the plurality of CPDLC-enabled avionics devices providing a second portion of the single CPDLC message that is different from the first portion of the single CPDLC message and corresponding to the navigational waypoint associated with component 1);

communicating the single CPDLC message to a CPDLC communications unit using a CPDLC context manager; and

at the CPDLC communications unit, transmitting the single CPDLC message to air traffic control.

8. The method of claim **7**, wherein activating the CPDLC mode comprises pressing a CPDLC activation key implemented on one of the CPDLC-enabled avionics devices and further comprising indicating the CPDLC mode on each of the CPDLC-enabled avionics devices subsequent to or concurrent with activating the CPDLC mode.

9. The method of claim **7**, further comprising storing the CPDLC message in a CPDLC message in/out buffer prior to communicating the CPDLC message to the CPDLC communications unit.

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